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ABSTRACT

This paper describes the Introductory Physics I and II courses taught by the author via the Kentucky Community and Technical College System's Kentucky Virtual University (KYVU). Students can register for a KYVU course either online or at their local college. Because many of the students are not highly computer literate, and they may be working on older machines, the courses do not require the latest software options. The author found some students had difficulty obtaining textbooks, and thus suggests that they order the books from his college's bookstore. The textbook used includes a CD. The class schedule includes a start-up week, which allows students the time to examine the materials and get a feel for the Web site, and to allow for late registrants. Exams are conducted online, and are unproctored. Homework is e-mailed to the instructor. The course includes a discussion feature that allows students to correspond in asynchronous time, and a chat feature that allows synchronous discussion. Because of the scattered geographic locations of students, the author chose activities that could be performed using inexpensive equipment that is readily available to students. The author surveyed students who took the course in spring 2002. The return rate was 30%. More than 78% of those students rated the class as excellent, and the successful completion rate for all sessions was 63%. (NB)

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Teaching Introductory Physics Online

Neil D. Adams

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Teaching Introductory Physics Online

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This presentation describes the Introductory Physics I and II courses taught online by the author during the past six semesters via the Kentucky Virtual University (KYVU). The syllabus, sample experiments, modes and methods of presentation will be included. Comparisons with traditional laboratories and lectures will include success rates, retention, and time commitment required from the instructor and students.

Introduction:

As part of the growth of the Kentucky Virtual University (KYVU), the Kentucky Community and Technical College System (KCTCS) decided to identify degree programs that could be offered entirely online. One of the programs selected by KCTCS was the Associate in Applied Science--Information Technology (Networking Option). Any program course that wasn't already offered online by a KCTCS college was then selected for development by a willing and able faculty member. The PHY 152, Introductory Physics II, and PH 162, Introductory Physics Laboratory II, classes were needed to complete this program. The College's Distance Learning Coordinator approached me in the summer of 2000 to develop these courses and after some indecision; I agreed to develop the course materials. In the Spring Semester of 2001, a colleague, James Meeks joined me in developing online versions of PHY 151 Introductory Physics I and PH 161, Introductory Physics Laboratory II classes.

PHY 151, 152 and PH 161, 162 are KCTCS' introductory physics courses designed to provide a physical science course option for non-science majors. It requires a math level of two years of high school algebra and no trigonometry. The topics covered in PHY 151 include the usual mechanics and heat. Topics covered in PHY 152 includes electricity and magnetism, optics, and modern physics. The laboratories, PH 161 and 162 provide laboratory experience related to the lecture topics.

Originally, I devoted my efforts toward finding a textbook with supporting computer supplements. Unfortunately, at the non-science major introductory physics level, there was not much available. Furthermore, there was no publisher provided computer supplements available for teaching the laboratory. The quality of the available materials was unsatisfactory; hence, the decision was made to do the course preparations of materials and experiments using college personnel.

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The KYVU provides the support services for these classes. This includes registration, and faculty support. The virtual university provides the server and a help desk for both students and faculty. They also have responsibility for obtaining a CMS site license. Although the faculty course developer may use other software, KYVU has selected WebCT as its preferred course management software. The courses were originally developed using course management software provided by Eduprise, but KYVU had to change its software choice when this company switched from being a software developer to being a support service. We have had four Course Management Systems (CMS), Eduprise, Prometheus, eCollege, and starting Fall 2002, WebCT. Hence, the present version of my courses is the fourth version of the first edition.

Students throughout all of Kentucky and elsewhere can register for a KYVU course either online or at their local college. Students in the introductory physics are primarily from the western portion of Kentucky. However, students from southern Illinois, southern Indiana, southern Ohio and western Tennessee are frequently on the roster. In addition, I have had a student in North Carolina and one in Greece; both however had local family connections. Many of the students taking courses from the KYVU are not highly computer literate and are working with older computers with limited software; hence, the courses don't require the student to have the latest software options. The reliability of local ISP's was also a factor in choosing the testing features. Although students are allowed only one test trial, those that are disconnected during their testing can contact the instructor and receive the opportunity to have a second chance. Many of the students are working full time and are endeavoring to keep up with their job, their home life and the course work. The deadlines suggested in the course calendar are basically guidelines for the student to use to try to keep on track with successful completion of the course by the end of the term. I do not enforce a strict policy for the timely return of homework, but have tried to stick with the deadlines for exams. However, I have waved this for a couple of childbirths.

The KYVU provides information to students about the textbooks for the courses but doesn't help them with obtaining their texts. Students can obtain their texts either from online sources or from the Paducah Community College Bookstore. A few students have had their local college's bookstore order a copy of the text, but this has not been an easy process. The biggest difficulty with using local bookstores has been the time delay between ordering the text and receiving it. In several cases, a student has waited as

much as a month to get their text. Online sources have also been unsatisfactory. The problem is usually one of getting the exact information. A mistake in the ISBN number or in the title can result in the student being told that the text is no longer available. As a result, I encourage students to use my college's bookstore. It will accept phone orders charged to a credit card and will mail books within a reasonable time.

Class Design: Lectures

The design plan for the lecture materials was to integrate the course material available on the KYVU site with the textbook and a CD that accompanies the textbook. The material on the website includes the course syllabus, the course calendar, the chapter materials, and the tests. The textbook, "The Physics of Everyday Phenomena: A Conceptual Introduction to Physics", 3rd Edition written by W. Thomas Griffith, and published by McGraw-Hill in 2001 was selected based upon the availability of the accompanying CD. The CD includes chapter learning objectives, practice quizzes, video clips, a glossary, and links to the McGraw-Hill web site for the textbook. Unfortunately, students that purchase a used version of the text may well not receive the CD that is part of the book package. Those that contact me can receive a copy of the CD, but frequently I don't hear from them about this.

The materials developed for the lectures included an introduction, a compilation of the learning objectives, lecture notes, solutions to some of the questions and exercises from the end of the text, chapter assignments, and suggested references and web links. The lecture notes are basically what I would include in my lecture and contain both material that is in the textbook and supplementary materials. For example, in Chapter 1, I do a much more detailed coverage of SI and the US Customary systems of units.

The Griffith book has 20 chapters with the first 11 covering material that is usually in a first semester course in physics. Hence, the two online courses cover 11 and 9 chapters respectively. The course calendar allows approximately one week for each chapter and the students are allowed one week for each exam and for the final. The schedule also has a built-in startup week so that they can use that time to explore the course materials and get a feel for the structure of the course and the web site. The startup week also is needed since the colleges that are part of the Virtual University have varying registration dates. Since students can register as early as mid October for the Spring semester, many will start to try gaining access to the course web site months ahead of the official start date. Unfortunately, many won't

register until the last day and for those students an early due date might well be before their registration. In addition, a startup week makes allowance for the two or three day delay in creating an official login and password for the student.

The exams are done online and are un-proctored. Since the students are scattered across the state and country, they are not required to come to campus for any test or session. The exam questions are primarily multiple choice. The tests are time limited and are available for a limited number of days. Students may take the exam only once, but as mentioned previously, allowances are made for students who have ISP problems. Four exams and a comprehensive final are required for each course during the Fall and Spring semesters. However, since the Summer session is only 8 weeks long, I do not require a final exam for that term. The course management system automatically grades all multiple-choice questions and will provide to the student their results. Correct answers are made available to the student after the end of the testing period.

Homework is emailed to the instructor either through the internal email system available on WebCT or directly to my college email account. I grade student work and return it with my comments and their grade on a daily basis. Students may seek help through the email system or they may select to use the Discussion feature. The Discussion feature allows the students to correspond in an asynchronous open format. They can leave messages to the class or they can correspond privately. The Chat feature allows synchronous discussions. Student use of the Discussion or Chat feature has varied with the semester, probably because some groups of students are more comfortable with going online than others.

Other than the security features built into the server at KYVU and at WebCT, no other efforts are used to control unauthorized sharing of testing information. The WebCT testing protocol allows the randomization of the answers and the corrected exam with answers can be hidden from the student until the end of the testing period. WebCT also allows the instructor to create a question databank and have the exam being made from a randomized subset of the databank questions. Previous versions of course management systems allowed the randomization of the order of the questions but not the order of the choices. I monitor the results of the testing to find evidence that there is wide spread sharing of testing information among the class members but over the six semesters I have taught these classes online I have found only one clear cut case of sharing. The class averages on the exams are usually in the mid seventies

and although there is a gradual rise in the exam average from one exam to the next during the semester, the highest exam average is still in the seventies. The isolation of the students from each other has helped to minimize the amount of cheating that occurs. The fact that the tests are time limited and the fear of losing Internet connections also discourages a student from opening a test and then searching out each answer. If a trend develops indicating that students are cheating at a higher and more effective rate, I will explore other options.

A student's grade is determined by his or her performance on the homework and the exams. About 8 homework problems are assigned from each chapter and about one week is allowed per chapter. A total of 89 problems are assigned for the first course and 58 are assigned for the second course. The homework counts ten percent of the final average. Regular exams count 60% and the final counts 30%of the student's average. During the summer, when I don't require a final exam, the exams count 90% of the final average. The college's policy allows a student to withdraw up till midterm and receive a W grade without the instructor's approval. After midterm, a W grade can be assigned if the instructor approves the student's request.

Class Design: Laboratories

The typical on-campus introductory laboratory class at Paducah Community College includes a combination of experiences designed to develop measuring skills, awareness of the limitations involved in measuring, analysis of data, developing conclusions and writing an appropriate laboratory report. During the course of each semester, lab students perform numerous hands-on activities designed to introduce them to a variety of instrumentation and to their operation. Each experiment includes activities that demonstrate common physics phenomena, validate lecture material, and analyze results.

In order to provide an equivalent set of experiences, I incorporated the same features as in on-campus classes into my online class. The selection of experiments is designed to emphasize one or more of the desired laboratory results; such as hands-on experience, data analysis, review of the literature, and the use of Java applets to provide guaranteed results. Dr Meeks or myself developed most of the experiments for the course. The remainder of the experiments are taken from the assigned text "Laboratory Manual: Conceptual Physics" 9th Edition written by Paul Robinson and Paul G. Hewitt, published in 2000 by Addison Wesley. Each experiment requires a written report with the data and results being included, and

a conclusion to gauge the student's comprehension of the principles covered in the experiment. Students must perform 10 experiments during the semester, choosing from a list of 12 or 13 experiments. Their interests, abilities and the availability of equipment dictate their choice. Although no particular order is enforced for the performance of the experiments, the numbering of the experiments parallels the order the materials appear in the lecture text.

I considered and rejected the idea of developing a lab equipment kit that the students could buy from the bookstore or borrow fromthe college. The typical bookstore manager would not want to have the responsibility of ordering equipment and assembling the kit. The number of students who would take the class each semester would not allow enough volume to achieve a reasonable price for a kit from a science supplier. Another factor would be the cost of shipping to multiple locations. About half of each lab class lives too far from Paducah to be able to drive to the Paducah Community College's Bookstore to buy a kit.

The experience of many schools with allowing students to borrow equipment for a class has not been encouraging. If the kit has to be mailed to the student and then mailed back at the end of the semester, the cost of postage can quickly eat up a department's budget. Returned equipment would have to be checked to insure that all parts have been returned and that their condition is suitable for the next student. This would require additional funds and time.

With students scattered all over the state, I chose activities that could be performed using inexpensive equipment readily available to the students so that they would not need to travel to Paducah. That also meant that not everyone would be using the same piece of equipment and there would be some students who could not obtain the necessary equipment. I selected experiments that used equipment that most students might find around their home or garage. I also suggested sources, Wal Mart, K-Mart, or Toys R Us, for example, for purchasing other items. I emphasize that they should not spend too much for these items over the semester. I suggested $30-$40 as a maximum per semester expenditure. I also told the students not to spend an excessive amount of time running around town looking for lab items. Furthermore, I have provided alternate experiments to replace anything that proves to be beyond the ability of the student to do or find. Most of the experiments also have numerous activities and the student is allowed to omit any procedure for which they have not been able to find the necessary equipment.

Wiring anything beyond a simple circuit proves very difficult for beginning students, hence, I decided to have the students use java applets for the electrical experiments. Virtual electrical experiments also have the advantage of being safe. Students access the appropriate link, incorporated into the course materials, and do a series of specified manipulations. The data analysis is designed to insure that the student is learning the concepts being illustrated. Other applets include experiments in optics and rectilinear motion. The applets I have used are in the public domain and include some developed as a result of a NSF conference at Davidson College in 1991. They also include applets that I have modified from those available at Davidson College. Depending upon the course management system, the students are linked to the Davidson site (http://webphysics.davidson.edu/applets/applets.html) or to an applet developed or modified by me and uploaded to the course web site.

One series of experiments was selected to develop the student's data analysis abilities. The students are given a table of position versus time from a free-fall experiment. They are then asked to determine the velocity versus time and the acceleration from this data. Results must include a graph. An alternative to this experiment involves taking data from an applet.

Finally, the student is assigned an experiment that requires them to do a "literature" search using the resources of the Kentucky Virtual Library (KVL) supplemented with an Internet search. They are to develop an estimate of their yearly exposure to radioactivity based upon where they live, work, and their lifestyle.

A student's grade in the laboratory is determined solely upon his/her grade from ten lab reports. Each lab report is graded for completeness, use of English, and accuracy of data analysis. Each report is to contain the following sections: Methods, Data & Results, Conclusions, and Assigned Questions. A report that is missing a content area or that has an unacceptably short content area will be penalized. The Data & Results section counts 60% of the report grade. The other three sections count 10% each. The quality of English usage on the report also earns 10% of the report grade.

Course Evaluation:

A survey of the students taking the online physics courses was completed in the Spring 2002 semester. The return rate was about 30%. Approximately 44% of the students in the class were first time Internet class students. Forty-four percent indicated that they occasionally needed assistance with the

technology. Two thirds of the responders indicated that they were taking the class online even though the class was taught on their local college campus. Many of the students are taking the online version of the course because they weren't able to register in an on-campus section. However, a significant number of students are taking the class as part or all of their college effort for that semester.

Enrollment in the summer term classes is frequently by students who return to their home in Paducah and wish to get college credit while working a summer job. They are likely to need to take a science class to complete their degree from their regular college. The introductory physics classes taught on KYVU during the summer are the only ones available in the state of Kentucky.

Students indicated that the quality of the course materials was high, at an appropriate level of difficulty, and that the support services for the course were always available. Students felt that the instructor-generated materials were helpful and clear. They indicated that the exams and assignments were related to the material covered. The instructor was judged to be prompt in answering questions, having a clear understanding of the subject matter and the technology. Overall, seventy-eight percent of the students rated the class as excellent. On a four-point scale, the students rated the courses a 3.91.

The success rate for students taking online physics has been comparable to those in a traditional lecture class. Over the six semesters, the successful completion rate has been 63%. Success is defined as a student completing the course with a C or better. Measurement of this rate is difficult since the commencement of the online course has coincided with a major change in governance of the Kentucky Community College System and the implementation of a new statewide registration program (PeopleSoft). The success rate for all Internet courses offered by Paducah Community College since Spring 1998 has been about 60%, so the online physics is well within the college norm.

The WebCT system allows the instructor to monitor student access to the course web site. The system can indicate the amount of time spent online and the dates of access. It is also possible to monitor the number of hits on the site by each student. At the middle of the Fall 2002 semester, the average number of hits is approximately 48. Thus the data indicates that successful students are spending a significant amount of time online. However, students can access the site and print out the materials and study from those. Consequently, it is not possible to provide a reliable estimate of the amount of time spent by the average student while studying the course.

An online class requires a significant investment of time and effort by the instructor. I devote about one to two hours each day responding to submitted assignments. I grade chapter homework and write notes to the student concerning their errors. As the homework arrives over a period of a week or more and I try to grade and return that work within a day of its submission, I am writing essentially the same message to a significant fraction of the students in the class. In a traditional class, all the homework, hopefully, would be turned in the same day and I would grade them all and return them to the class and make my remarks once to the entire class. This part of the daily class maintenance activities accounts for the most significant portion of time spent on the class. I frequently send blanket emails with announcements and reminders. From the beginning of registration to after the end of the course, I will have to respond to student inquiries.

Unfortunately, the most significant amount of time has been devoted to developing the courses and migrating or revising various versions as the KYVU has found it necessary to choose new CMS providers. Although cut and paste has made successive versions easier in some ways, each CMS has its particular quirks that require the developer to closely review everything and make necessary changes. Each change has also meant that I have had to go through a learning process. The KYVU provides workshops each spring for faculty wanting to offer online courses and needing to learn the CMS, some of which have been easily learned and others not.

Fortunately, the present textbook for the lecture has not been changed, but a significantly altered edition of the Griffith text could result in a major rework effort. A change in the lab manual was not as difficult because the primary changes between the 8th and 9th edition of the Robinson and Hewitt book were to add some experiments. As a result, the changes in the course website only involved changing the page numbers.

The time commitment required of the faculty per semester for each course is probably 2 to 3 times the time needed to teach the same course on campus. Some of the extra time can be attributed to the need to develop new versions of the website. Unfortunately, this extra effort is not adequately factored into the workload calculation for the instructor. The normal workload in the Kentucky community college system is considered to be 15 semester hours per semester. Some adjustment is made for instructors who teach

laboratory classes. However, a three-semester hour class taught online will be considered equal to the same course taught in a traditional classroom.

Conclusions:

All of the available data indicates that teaching physics online has been successful. It is possible to offer a high quality learning experience in physics. Both lectures and labs can be successfully taught to students who are isolated from the traditional college campus. The amount of work required from the student appears to be approximately what that student would have to devote to taking a traditional section of the same course. The work required of the faculty is significantly greater, but as the process stabilizes, the work involved may settle to a lower level.

In order to avoid instructor burnout, I recommend that the course development not be tied heavily to a particular textbook or CMS. Development is probably best when the material is written in a word processing program and then pasted into the CMS. Changes required as a result of an edition change are also easier to handle when the material is not inexorably entwined with the material in one book. My on campus class lectures are much the same year to year whether the edition or book is changed. Website materials probably should be equally generic. Future versions of this course will be even more independent of the book. The order of the material and the homework assignments will be linked to the web site materials and the textbook.

As the availability of software for quick and efficient delivery of video material improves, a greater amount of video material will be incorporated into the course materials. A major need is to have short video clips with demonstrations to illustrate more of the phenomena. For lab experiments, start and stop video segments will allow the student to take measurements directly from their computer monitor. This would make the lab experiment more realistic while allowing them to observe a properly performed experiment using more up-to-date equipment.

Finally, for those students who take the lab, the experience of performing experiments that provide reasonably accurate results using on-hand equipment is a positive accomplishment. Many students come away from a laboratory course thinking that lab can only be done in a lab with equipment that is not readily available to the average person. I developed these labs based upon on-hand equipment because of the problems associated with providing equipment to students in their homes. However, I have found that an

unforeseen side effect of having the students find their own equipment is that many have had an awaking to the fact that they don't need high technology to investigate and learn about their physical environment. In other words, this has resulted in a contradiction: Using high technology in order to disseminate information has resulted in students that are better able to use low technology in their everyday activities.

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